FDOT TRANSPORTATION SYMPOSIUM 2019

District Drainage Engineer Roundtable

Erin Yao, James Poole, & Miranda Glass

FDOT TRANSPORTATION SYMPOSIUM 2019

HYDROPLANING – IT’S A SLIPPERY SLOPE

(Lessons Learned from Florida’s Turnpike Enterprise)

Erin Yao, PE, CFM
FDOT-Turnpike

FDOT TRANSPORTATION SYMPOSIUM

OVERVIEW

- Assessing Hydroplaning Risk
- Update on NCHRP Hydroplaning Research Project TRB-NET NCHRP 15-55
- Update on FDOT State Materials Office Enhancements to Hydroplaning Software
- HNTB Hydroplaning Crash Study and Mitigation Strategies (Ph I and II) Overview
- Lessons Learned/How to Proceed
- Questions?

HYDROPLANING RISK-WHAT IT IS AND HOW TO ASSESS

- Evaluation Determines Risk for Typical Sections/Critical Locations (Un-grooved Bridges, SE transitions, Aux Lanes, Express Lane buffers, Paved Shoulders, Paved Gores, etc.)
- Input: Design Speed, Pavement cross slope, longitudinal grade, effective pavement width, Mean Texture Depth
- Predicts Water Film Thickness (WFT) & Predicted Hydroplaning Speed (Several Intensities) to be compared against Predicted Driver Speed
- Hydroplaning Tool: https://www.fdot.gov/roadway/Drainage/ManualsandHandbooks.shtm

Design Aids

DrConnPermitHB.pdf	Drainage handbook for the preparation of Drainage Connection (14-86) permit application package - 2mb size	9/7/17
Erosion-Sediment-Control.pdf	Erosion and Sediment Control Manual - 90mb size - 2010 Version; Effective June 2007: Last Update July 2013	7/1/13
Stormwater Quality	Environmental Resource Permit Stormwater Quality Applicant's Handbook	3/17/10
Hydroplaning.zip	Hydroplaning Tools (***424mb zip file size***) *Note** If you experience issues with the installation of this application, please contact the Drainage Office at (850) 414-4310*	
sdtab2008.pdf	Storm Drain Tabulation Form	7/1/08
IDFCurves.pdf	Drainage Manual - IDF Curves and Rainfall Distributions	12/10/15

NCHRP RESEARCH PROJECT: TRB-NET NCHRP 15-55

- Developing National Guidance to Predict and Mitigate Dynamic Hydroplaning on Roadways, to include a tool to help agencies reduce hydroplaning risk
- Final product will include guidance and tools to predict and mitigate risk on roadways.
- Guidance will be applicable to all types of roadways, including site-specific factors such as maintenance/retrofit projects.
- 2 Phase Study
  - Ph I determined which sub-models to use and included a report (completed December 2015)
  - Ph IIA included initial model verification, a prototype tool, a report, and a panel meeting (completed 2016)
  - Ph IIB includes the full integrated model validation, and development of the final tool. A list of solutions will be developed to reduce risk, including costs, drawbacks, and benefits (anticipated this year)
- For more information: TRB-NET NCHRP 15-55 http://apps.trb.org/cmsfeed/trbnetprojectdisplay.asp?projectid=3870

FDOT SMO HP SOFTWARE ENHANCEMENTS

- Enhancing current HP program to include the following:
  - Calculate hydroplaning risk continuously along roadway with geometry/MPSV/texture data inputs
  - Integrate hydroplaning calculations with GIS to view hydroplaning risk contour plots
  - Analyze multiple proposed lanes (planes) and storm events simultaneously
- Deliverables: Final Report, HP program, user manual, source code, install instructions, and CBT course
- Schedule:
  - Start Date: May 2018
  - Received two initial reports to date:
    - Task 1 (review of existing tool and needed improvements, sensitivity analysis, and development of MPD and MTD relationship)
    - Task 2 (methodologies and work plan to upgrade current HP software)
  - Anticipate completion by December 2019
- Implementation/Policy: TBD based on coordination with CO

HNTB'S STUDY OF HYDROPLANING

[Phase 1 Link]

[Phase 2 Link]

PART I – CRASH STUDY

- Analyzed existing wide typical sections throughout Florida
  - Turnpike system
  - Interstate system
- Crashes attributable to hydroplaning
  - Crash reports
  - Long forms
- Site conditions
  - Running speed during crashes
  - Rainfall intensity during crashes
  - Geometric conditions

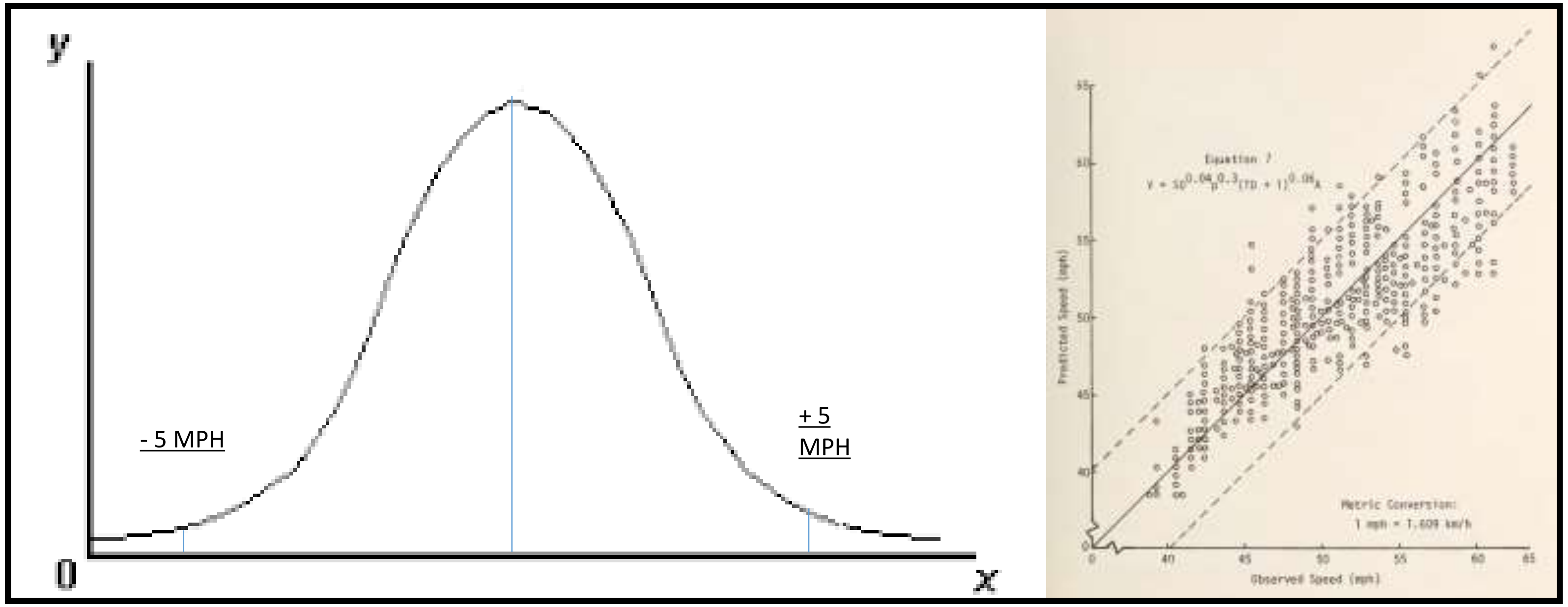
HYDROPLANING MITIGATION TRIGGER

- Hydroplaning Calculator
  - When the calculated speed of hydroplaning < predicted driver speed during a given rainfall event.

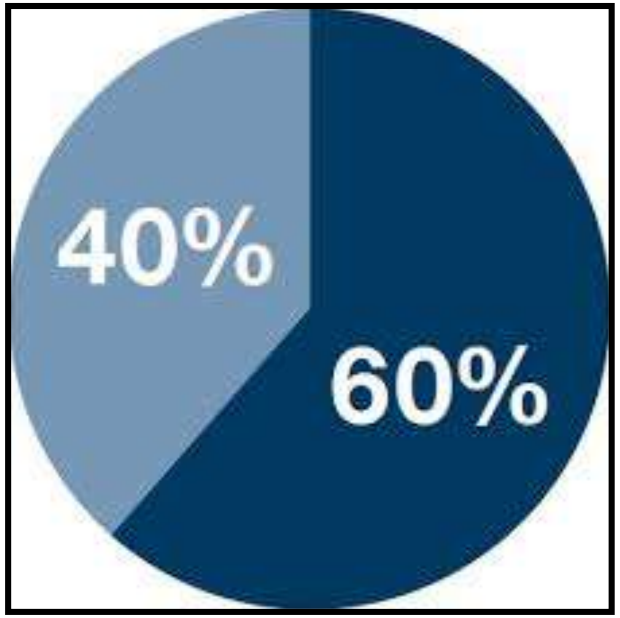
12-Lane Section - No Mitigation									
Design Speed	Intensity	xslope	Longitudinal slope	Width	MTD (mm)	Gallaway (WFT) (in)	Hydroplaning Speed	Predicted Driver Speed	Speed Diff (MPH)
70	2	0.045	0.02	72	1.5	0.05	56	58	-2.1
70	2	0.045	0.02	60	1.5	0.04	59	58	1.1
70	2	0.045	0.02	48	1.5	0.03	64	58	5.9
70	2	0.045	0.02	36	1.5	0.02	73	58	15.0
70	2	0.045	0.02	24	1.5	0.00	109	58	51.1
70	2	0.045	0.02	12	1.5	-0.02	N/A	58	N/A

REVIEW OF GALLAWAY AND PAVDRN EQUATIONS

- PAVDRN hydroplaning speed equation
  - Gallaway hydroplaning speed formula is foundation for PAVDRN hydroplaning speed equation and has a +/- 5 MPH variance between calculated hydroplaning speed and observed hydroplaning speed (Gallaway, 1979)
  - PAVDRN equation is accurate in predicting a hydroplaning crash more than 60% of the time (Yassin, 2013)



Gallaway Hydroplaning Speed vs. Observed Hydroplaning Speed (85% Correlation) (Gallaway, 1979)



PAVDRN Accuracy (Yassin, 2013)

REVIEW OF GALLAWAY AND PAVDRN EQUATIONS

- Other factors that influence speed of hydroplaning
  - Tread depth assumption
    - 3/32” (tread wear indicator 2/32”)
  - Tire pressure assumption
    - 24 psi (picture)
  - Tire design
    - Improved tire design since 1979
  - Driver input
    - Reasonable and prudent action on the part of the driver (hydroplaning tort law)
  - Vehicle enhancements
    - Anti-lock breaks
    - Stability control
    - Traction Control

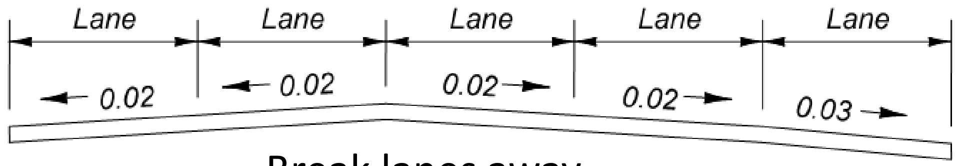
24 psi

PHASE I OBSERVATIONS

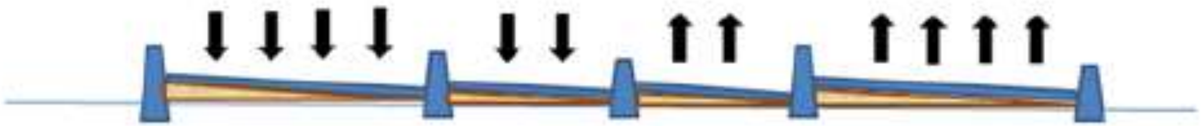
- Wider typical sections had 34% of wet weather crashes compared to about 12% of wet weather crashes in the 6-lane sections
- Hydroplaning crash frequencies were greater in the lower lanes than the higher lanes
- For some of the sections, adjacent lane to the lowest lane had slightly higher crash frequency than the lowest lane as some of the lowest lanes are auxiliary lanes
- 65mph design speed is a key factor in the hydroplaning formula that shows red flag
- Speeds observed shows drivers travelling at higher than posted speed limits at the time of crashes
- The observed speeds were also above the predicted hydroplaning speed based on the formula
- Weather stations in south Florida show approximately 36% of rainfall events are over 1.5-in/hr

PART II – MITIGATION STRATEGIES

- Roadway Geometry
  - Cross Slope (reconstruct curve roadway to get superelevation that will pass or help hydroplaning)
  - Effective Pavement Width (reduce number of lanes in one direction to reduce water film thickness)
    - Break lanes away from each other
    - Separate lanes
    - Elevate roadway



Break lanes away

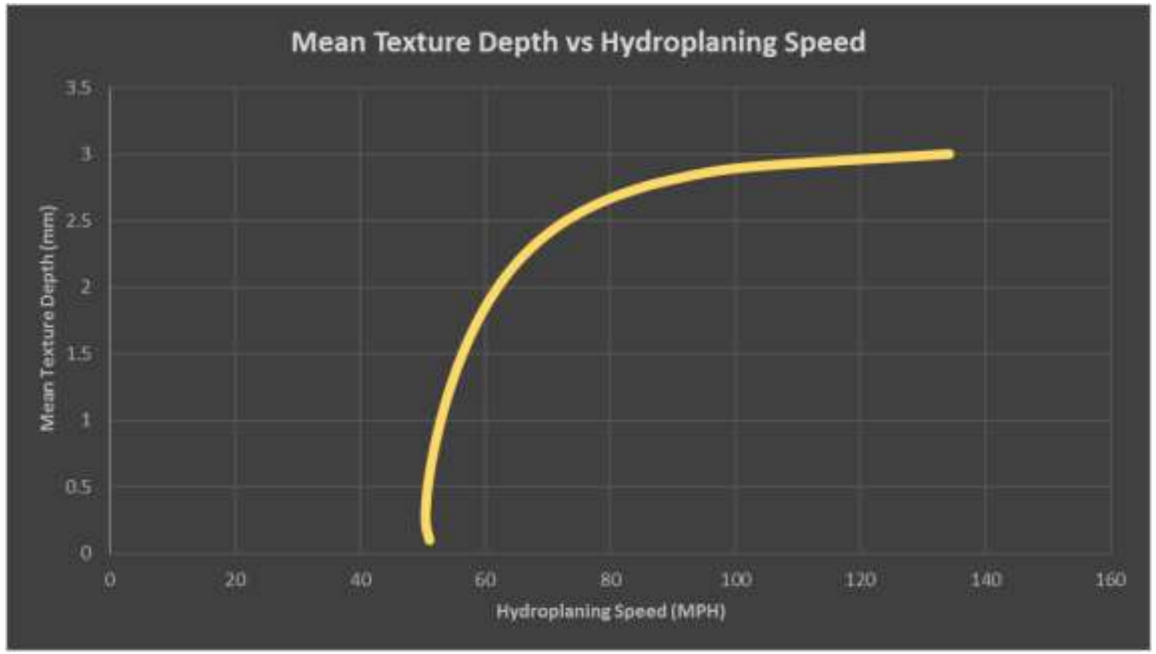


Barrier separate

FDOT TRANSPORTATION SYMPOSIUM

- Pavement Design
  - Grooved Concrete Pavement
  - Improved Asphalt Pavement Designs

- Mean texture depth is the most influential factor in the HP Tool.
- Alternative pavement types should be coordinated closely with Department staff.



Effects of MTD on hydroplaning speed; all other parameters held constant: Ds = 70 MPH, Intensity = 2 in/hr, Cross Slope = 4.5%, Pav't Width = 72 ft, Grade = 0.300%

Hydroplaning analysis tool uses average MTD based on pavement type. Actual values vary based on specific mixture and pavement condition over time. Typical range is +/- 2mm which produces a +/- 2 MPH variability in speed.

PART II – MITIGATION STRATEGIES

- Signage (Cost effective and easy to install/modify)
  - Dynamic message
  - Variable speed limit
  - Advanced warning with flashers and rain sensors

BENEFIT/COST RATIO ANALYSIS

- B/C Ratio = $\frac{savings\ from\ reduced\ hydroplaning\ crashes(CMF \text{ x } crashes\ of\ design\ life)}{cost\ to\ implement\ mitigation\ strategy}$
- Requires:
  - **<u>Crash modification factor (CMF)</u>**
  - Existing crash data
  - Design life of project
  - Existing traffic data
  - Avg. cost per crash
  - Cost of initial implementation
  - Cost of additional long term maintenance

- Use “Star” rated CMF’s first then “zero-star” rated CMF’s (work with Safety Staff if CMF not available)
- Provide at least 3 strategies for comparison
- Provide recommended mitigation strategy based on best b/c ratio and least impact to site and schedule.
- CMF Limitations:
  - CMF’s are not available for all mitigating strategies
    - CMF must be established prior b/c ratio calculation
  - Cost of implementation is not always straight forward
    - R/W costs
    - Reconstruction costs
    - Utility relocation costs
    - Schedule delays
    - New technology
    - Long term maintenance costs

CONCLUSIONS

- Work closely with FDOT to determine if risk needs to be evaluated and to reach a solution
- Address hydroplaning early using HP Software
- Prepare mitigating strategies and Cost/Benefit where necessary
- Engage Safety Staff to assist in determining CMFs
- Review the HNTB Hydroplaning Crash Study and Mitigation Strategies (Ph I and II) Overview
- Hydroplaning risk may not be completely mitigated
- Current hydroplaning crashes are occurring well above the predicted driving speed
    - Mitigating to predicted driving speed may provide limited practical benefit at observed running speed
    - Mitigating to observed driving speed can be cost prohibitive
    - ITS/Signing warning messages and law enforcement may be effective mitigation strategies
- Mitigation strategies should consider adverse effects to dry weather conditions
- Future research may be needed for different pavement designs and modern vehicle types

QUESTIONS?

Questions?

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FDOT TRANSPORTATION SYMPOSIUM 2019

Environmentally Friendly Design

James Poole, District Four Drainage Engineer

Environmentally Friendly Design

OUR MISSION

The department will provide a safe transportation system that ensures the mobility of people and goods, enhances economic prosperity, and preserves the quality of our environment and communities.

Our Vision

As one FDOT team, we serve the people of Florida by providing a transportation network that is well planned, supports economic growth, and has the goal of being congestion and fatality free.

Our Values

The fundamental principles which guide the behavior and actions of our employees and our organization.

Integrity
"We always do what is right"

Respect
"We value diversity, talent and ideas"

Commitment
"We do what we say we are going to do"

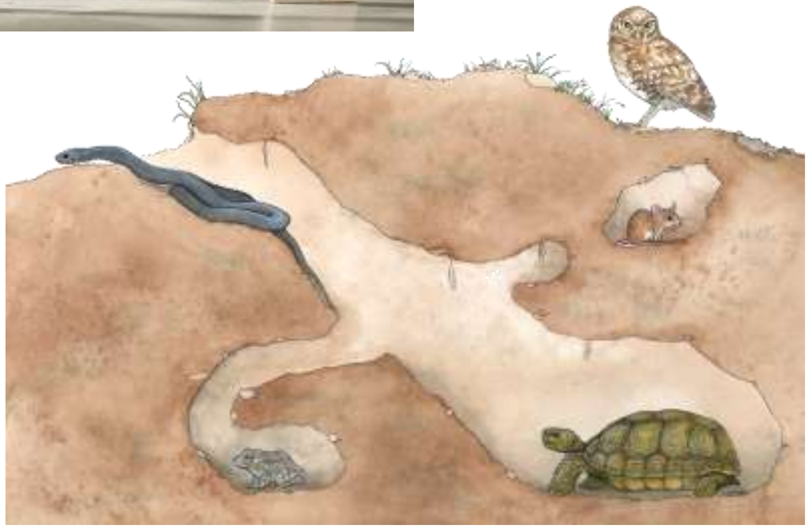
One FDOT
"We are one agency, one team"

Trust
"We are open and fair"

Customer Driven
"We listen to our customers"

Case Study: A Tortoise Saving *Sidewalk Alignment*

Gopher Tortoise

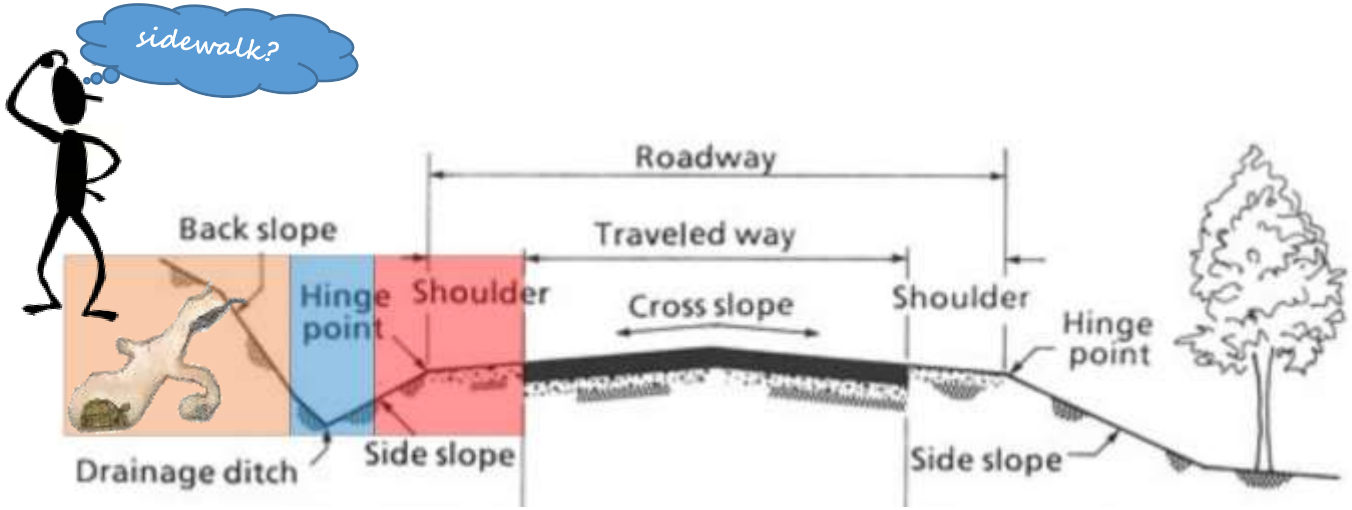


Gopher Tortoise

NATIONAL GEOGRAPHIC Instagram

Photo by Joel Sartore @joelsartore | Gopher tortoises face a potentially deadly journey when they cross busy highways, so please slow down in known tortoise areas. The creatures play a key role in helping other species survive; the burrows dug by this reptile act as shelter for an assortment of animals native to the southern U.S. They are listed as federally threatened and also as vulnerable by the IUCN, but collisions with vehicles are a leading cause of death for the gopher tortoise, which often must cross roadways in order to forage, find a mate, or dig a new burrow.

Who's going to compromise?



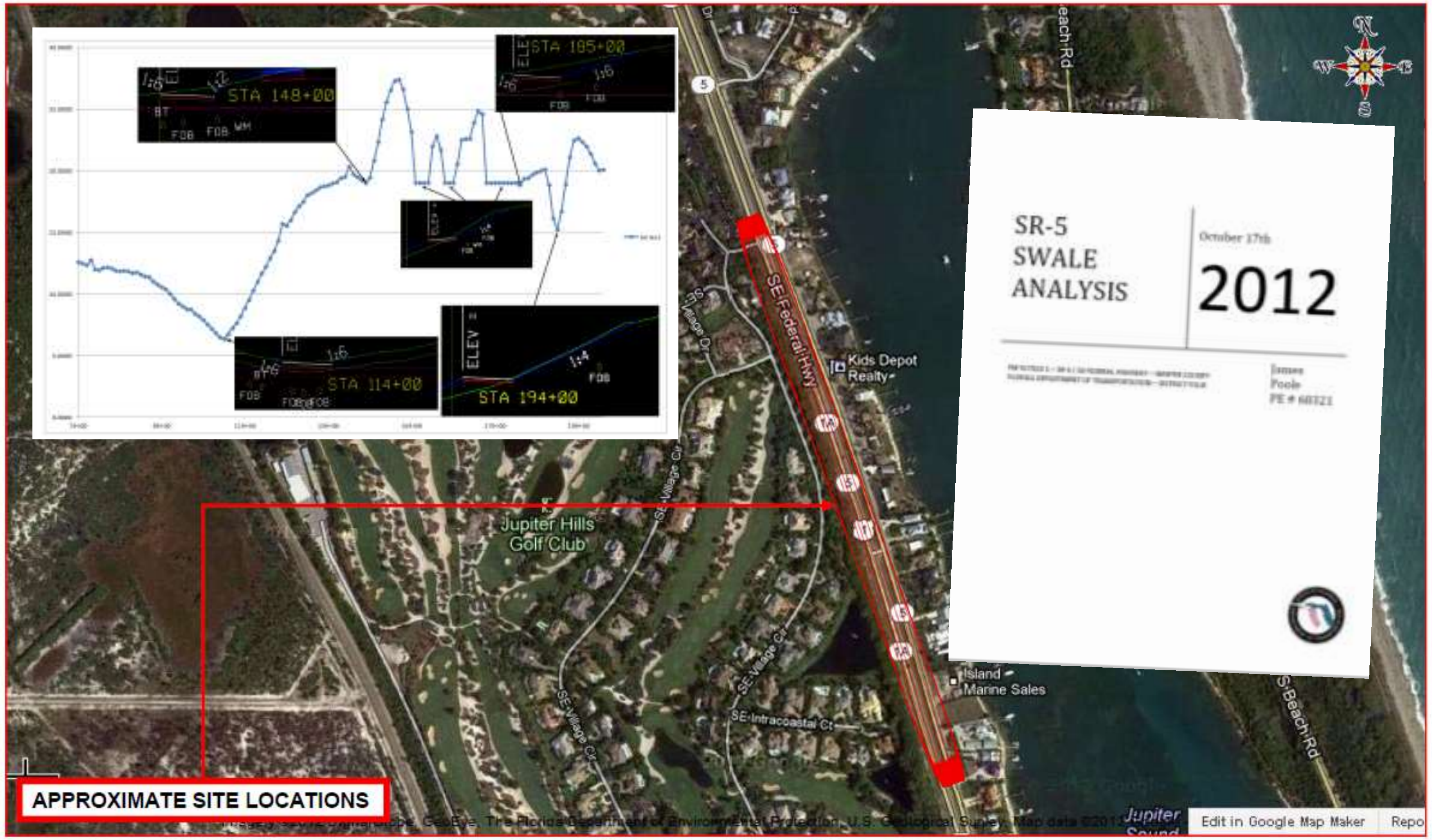
- "Back slopes" are inhabited by gopher tortoises
- Drainage "ditch" needed for runoff
- Shoulder area is too close to the road

Teamwork Opportunity

- Burrow locations and scrub boundaries identified (Environmental Management)
- Drainage analysis completed for feasibility (Drainage Design)
- Pay item added for pervious pavement (Project Manager)

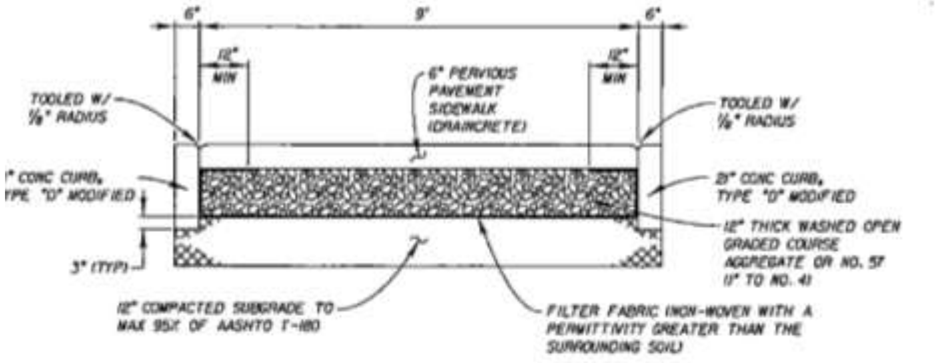
Environmentally Friendly Design

SITE VICINITY MAP



GEOTECHNICAL ENGINEERING SERVICES S.R. 5/U.S.-1 from County Line Road to MP 5.030 Martin County, Florida FPID No.: 427023-1-52-01	DATE: 10/12/2012 DRAWN: JC	psi Information To Build On Engineering • Consulting • Testing
SHEET No.: 1 — PSI PROJ. No.: 0397-500	CHKD: MG	

Pervious Sidewalk



PERVIOUS PAVEMENT (DRAINCRETE) DETAIL

NOTES:

1. CURB TYPE "D" MODIFIED MAY BE CONSTRUCTED INTEGRAL WITH THE SIDEWALK AT NO ADDITIONAL COMPENSATION.

2. CONTRACTOR IS ADVISED THAT BURIED FIBER OPTIC AND BURIED TELEPHONE LINES ARE WITHIN THE PROPOSED PERVIOUS PAVEMENT SUBGRADE OR IN THE IMMEDIATE VICINITY OF PROPOSED PERVIOUS PAVEMENT CONSTRUCTION. CONTRACTOR SHALL EXERCISE DUE CAUTION IN CONSTRUCTION OF PERVIOUS PAVEMENT TO AVOID DAMAGE TO EXISTING UTILITIES, INCLUDING, BUT NOT LIMITED TO, MANUAL EXCAVATION AND MANUAL SUBGRADE COMPACTION. SEE PAY ITEM NOTE 160-4.

3. A MINIMUM OF 2 NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA) CERTIFIED PERVIOUS CONCRETE TECHNICIANS SHALL BE PRESENT AT THE SITE DURING ENTIRE TIME OF PLACEMENT OF PERVIOUS PAVEMENT, CAPABLE OF DEMONSTRATING KNOWLEDGE BY PLACING ONE TEST PANEL, TO BE A MINIMUM OF 225 SQUARE FEET AT THE DESIGNED PROJECT THICKNESS, USING PROPER INDUSTRY EQUIPMENT FOR PORTLAND CEMENT PERVIOUS CONCRETE OR A MINIMUM OF 1 NRMCA CERTIFIED PERVIOUS CONCRETE CRAFTSMAN AT THE SITE DURING THE ENTIRE TIME OF PLACEMENT, NO TEST PANEL IS REQUIRED.

4. THE CONTRACTOR SHALL PROVIDE MECHANICAL STRIKE-OFF EQUIPMENT OF EITHER SLIP FORM OR FORM RIDING WITH A FOLLOWING COMPACTIVE UNIT THAT WILL PROVIDE A MINIMUM OF FORTY (40) POUND PER FOOT VERTICAL FORCE. IF PLACING EQUIPMENT DOES NOT PROVIDE THE MINIMUM SPECIFIED VERTICAL FORCE, A FULL WIDTH ROLLER OR OTHER FULL WIDTH COMPACTION DEVICE THAT PROVIDES SUFFICIENT COMPACTIVE EFFORT SHALL BE USED IMMEDIATELY FOLLOWING THE STRIKE-OFF OPERATION. AFTER MECHANICAL OR OTHER APPROVED STRIKE-OFF AND COMPACTION OPERATION, NO OTHER FINISHING OPERATION WILL BE ALLOWED. DO NOT USE STEEL TROWELS OR POWER FINISHING EQUIPMENT. IF SURFACE VIBRATION IS USED, IT SHALL BE SET AT THE LOWEST FREQUENCY DURING PLACEMENT AND IT SHALL BE SHUT OFF IMMEDIATELY WHEN FORWARD PROGRESS IS HALTED FOR ANY REASON. SURFACE SHALL MEET ADA REQUIREMENTS.

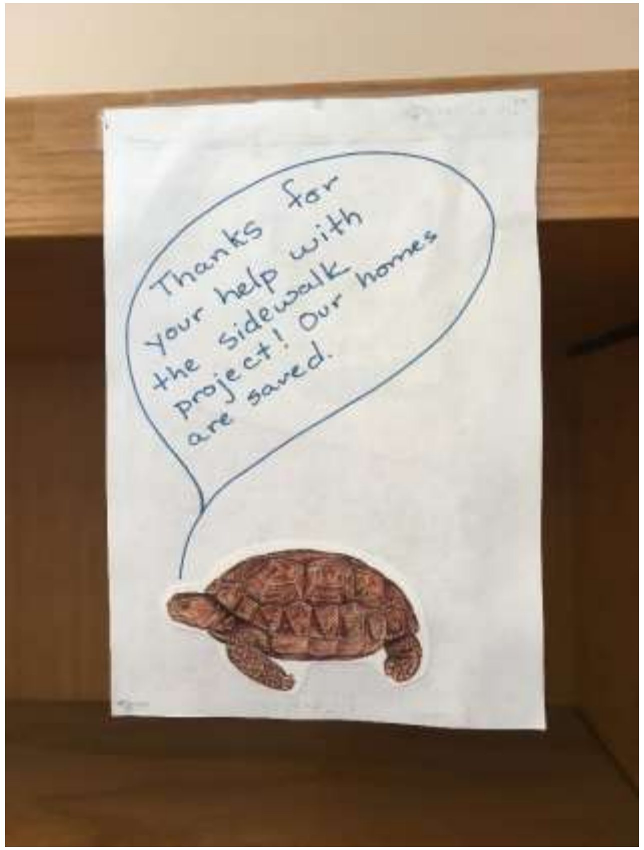
Quick Sidebar: An Age-old Debate

- Is temporary sidewalk flooding ok?
- Is it reasonable to expect pedestrian traffic during a design event?

Sidebar from the sidebar:

- Pervious sidewalks aren't as smooth…but the tortoises!

We saved the burrows!



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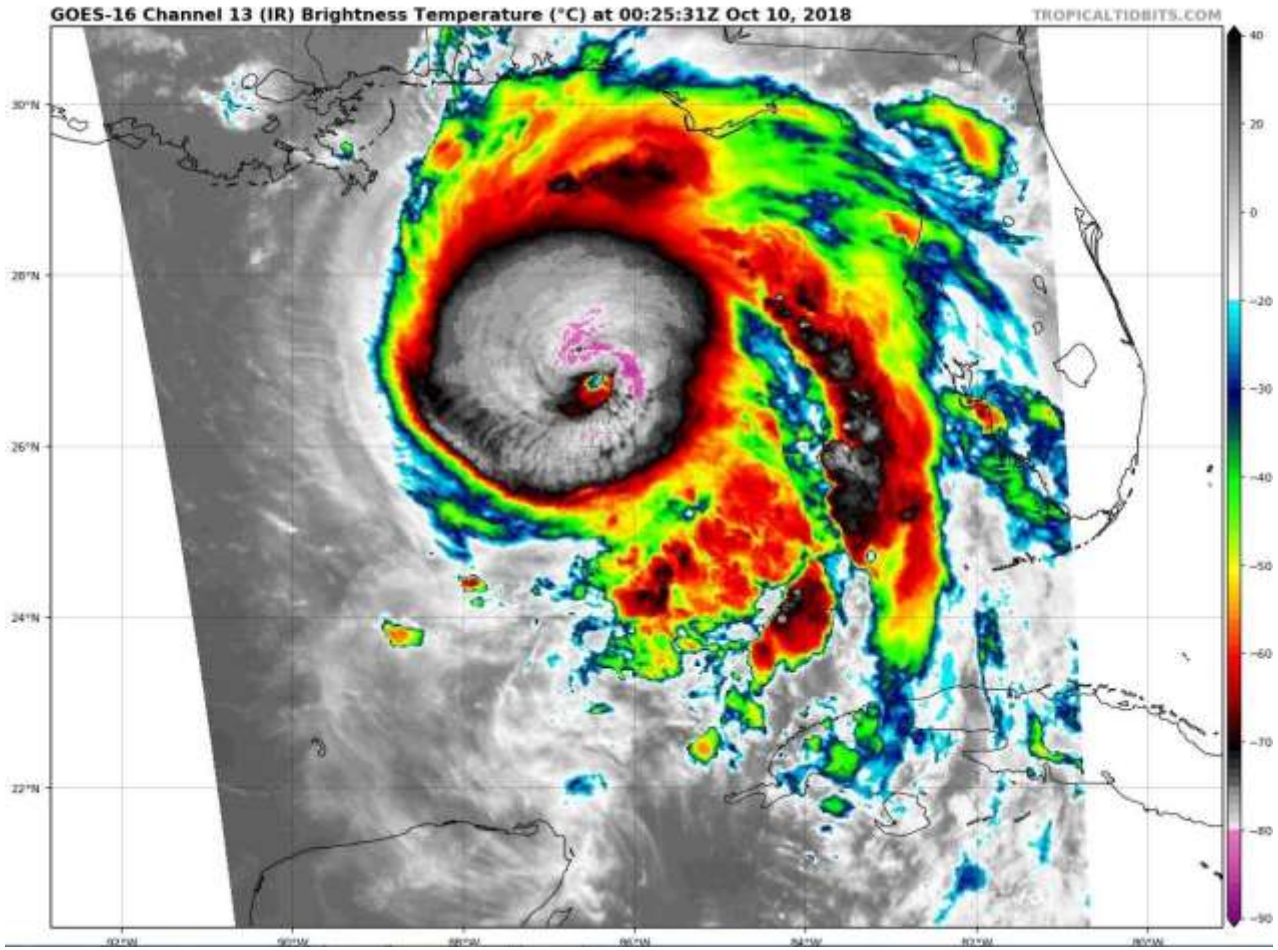
The Aftermath of a Category 5 Hurricane

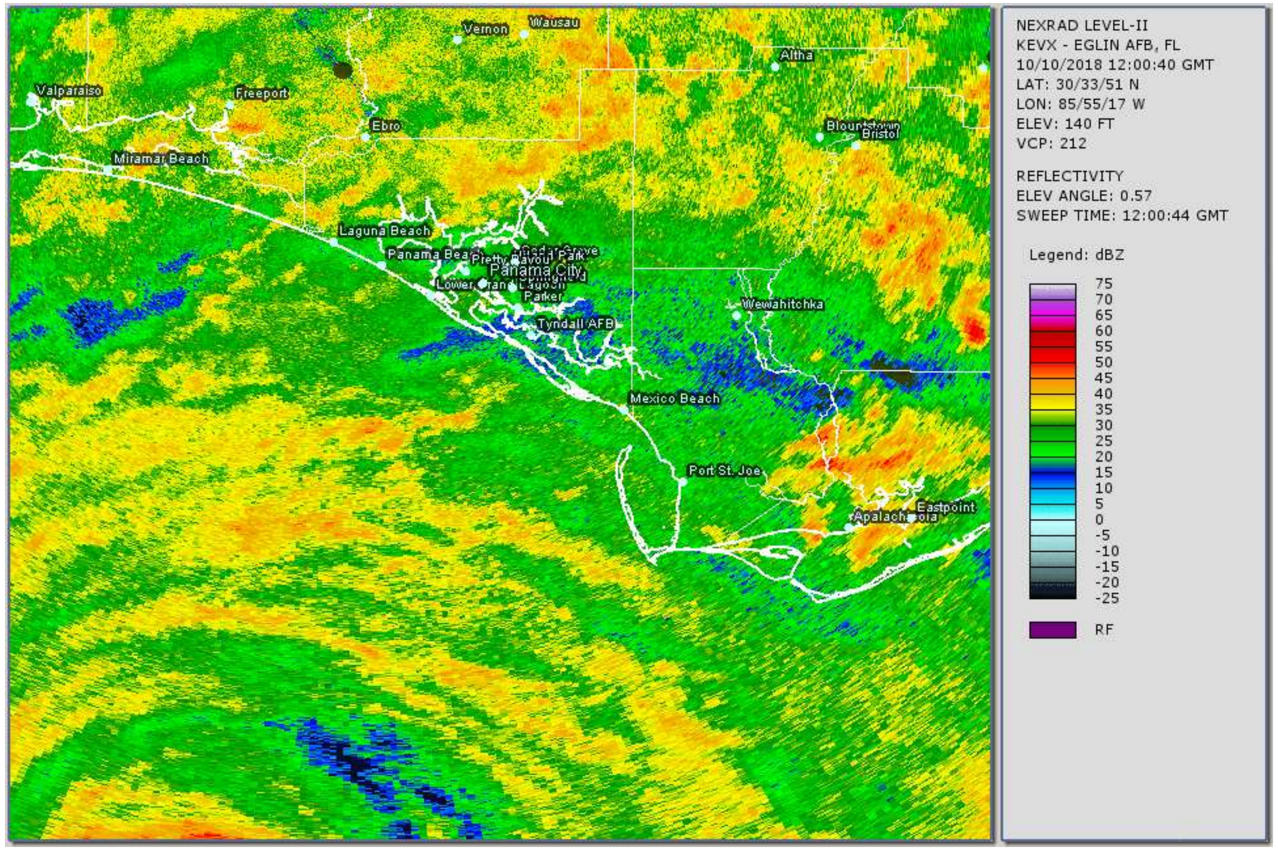
Miranda Glass, District Three Drainage Engineer

Hurricane Michael



- Fourth most powerful hurricane to hit the United States
- Strongest hurricane on record to make landfall in the Florida Panhandle
- National Weather Service in Tallahassee issued its first ever Extreme Wind Warning

Hurricane Michael



- Landfall near Tyndall Airforce Base and Mexico Beach (October 10, 2018)
- Caused catastrophic damage from wind and storm surge
- Inland flooding limited overall
- Highest rainfall amount in Florida in Calhoun County with 6.66”

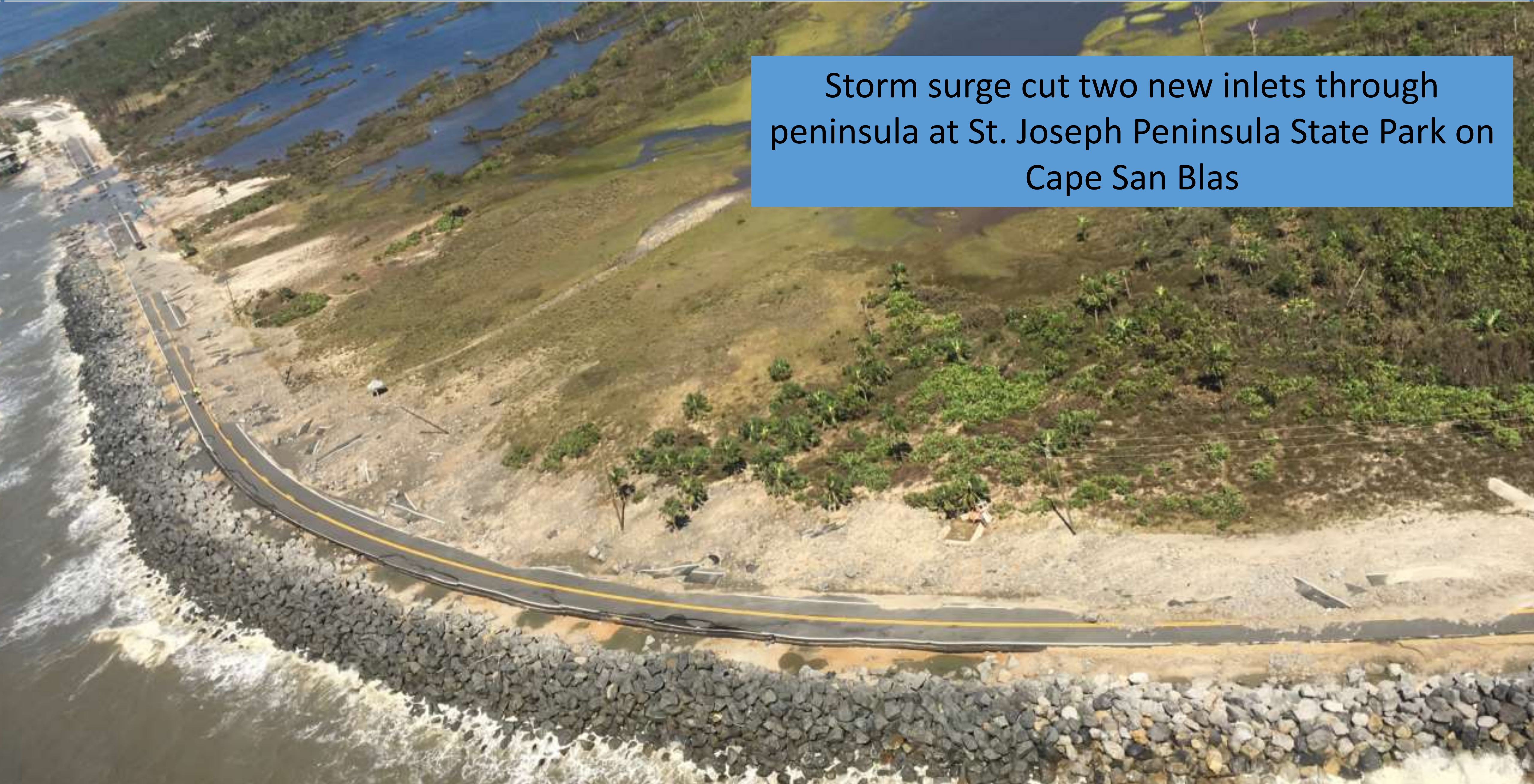
- Peak storm surge of 9-14 feet inundation observed
- Wave heights impacting second stories of multiple buildings in Mexico Beach

- Significant debris
- Millions of acres of forest land damaged
- Staging of debris for pickup impacting drainage
- Erosion and changes in runoff

FDOT

Damage Footprint

Stump Hole

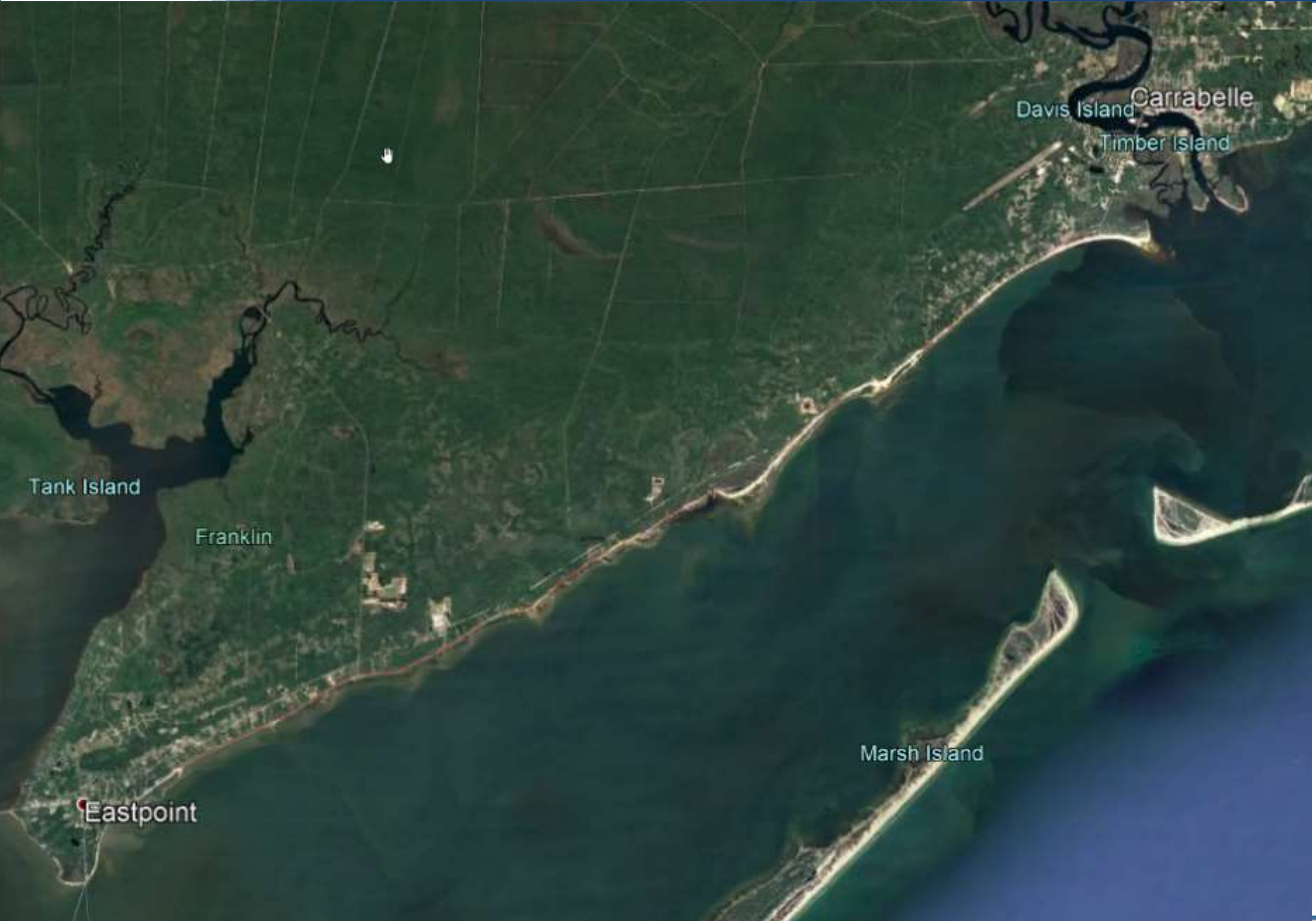


Storm surge cut two new inlets through peninsula at St. Joseph Peninsula State Park on Cape San Blas

Stump Hole

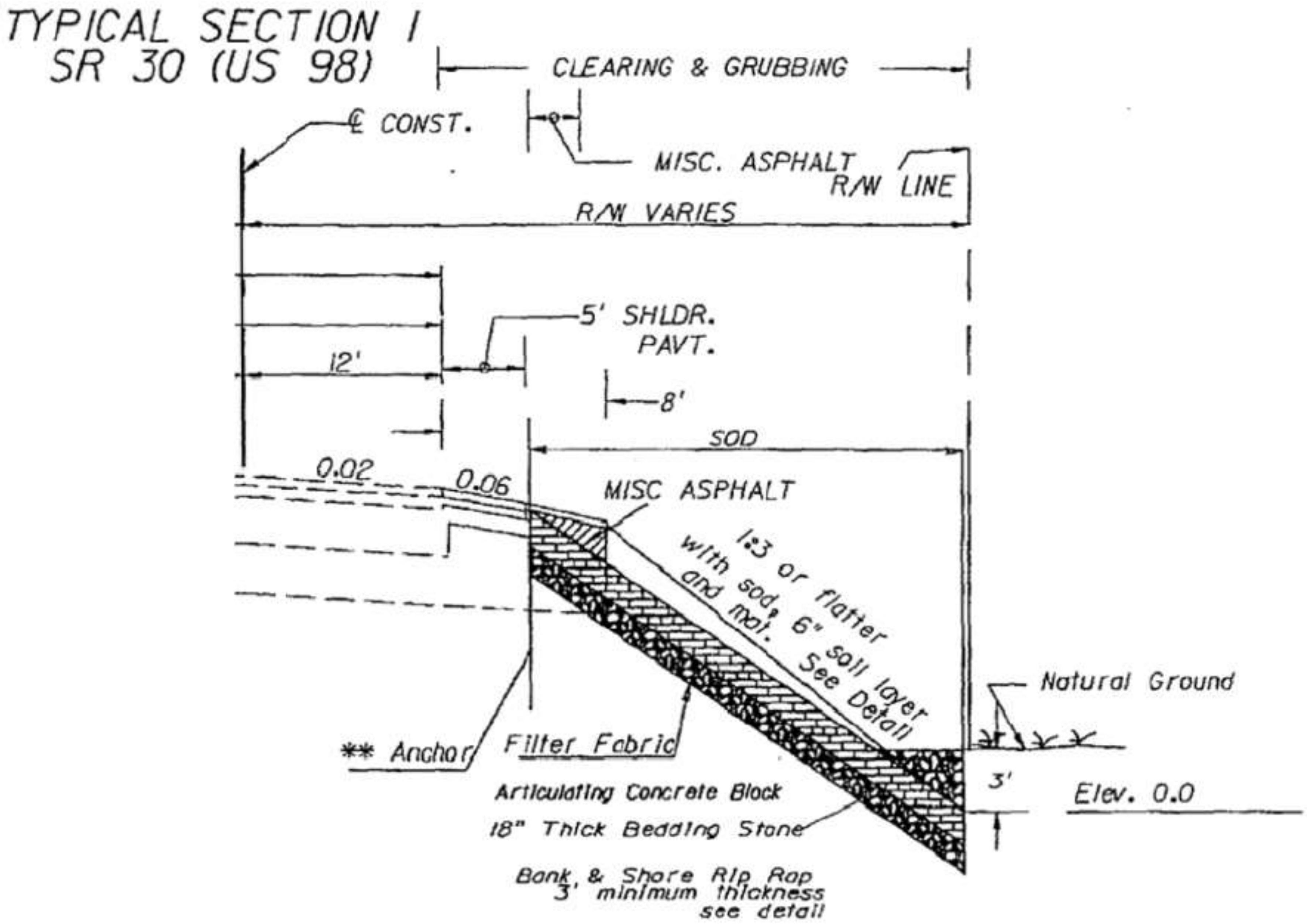
Cape San Blas

US 98

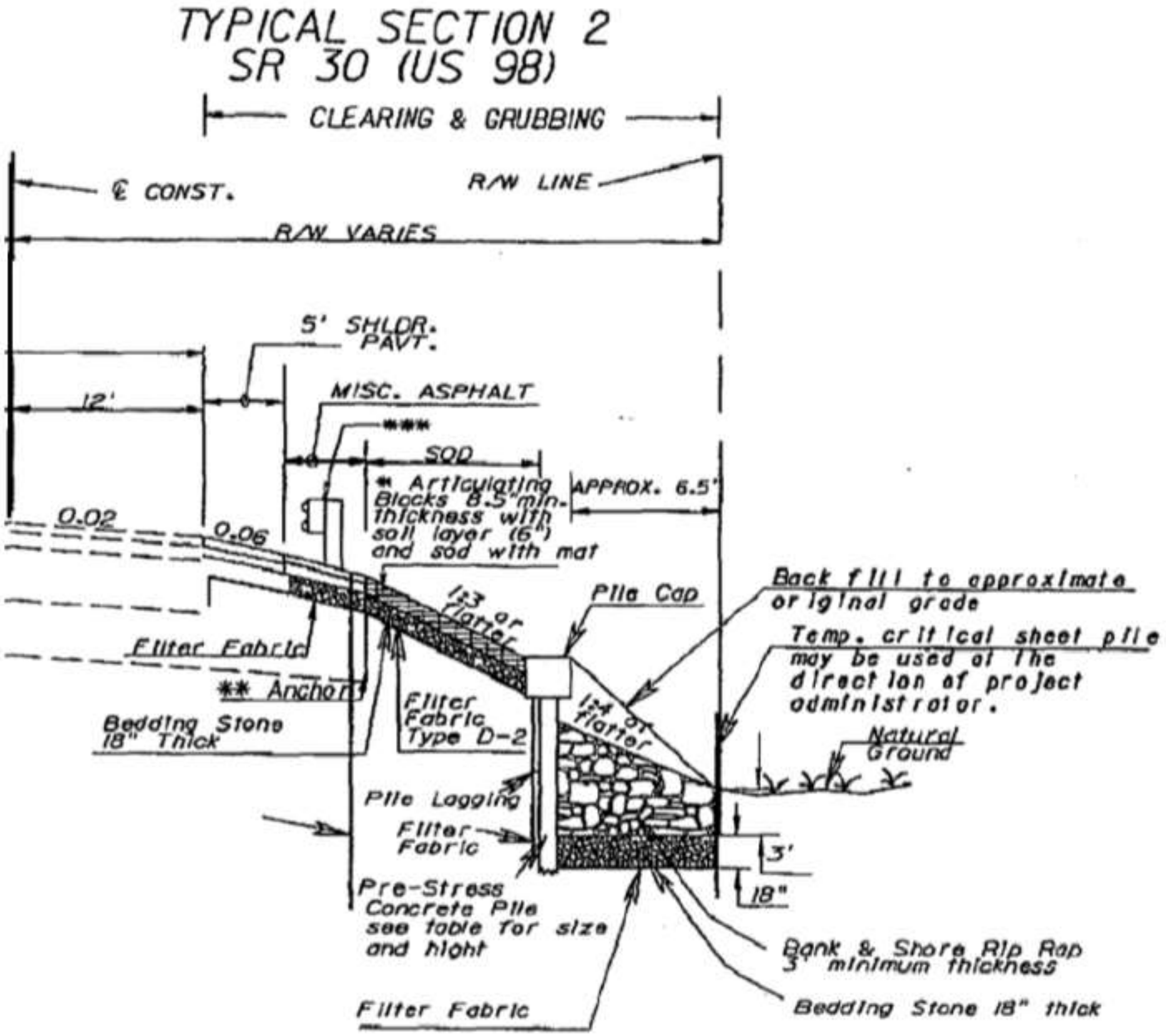


- Franklin County US 98 Revetment
- 2007 Permanent Repair Project
- Lessons Learned

US 98

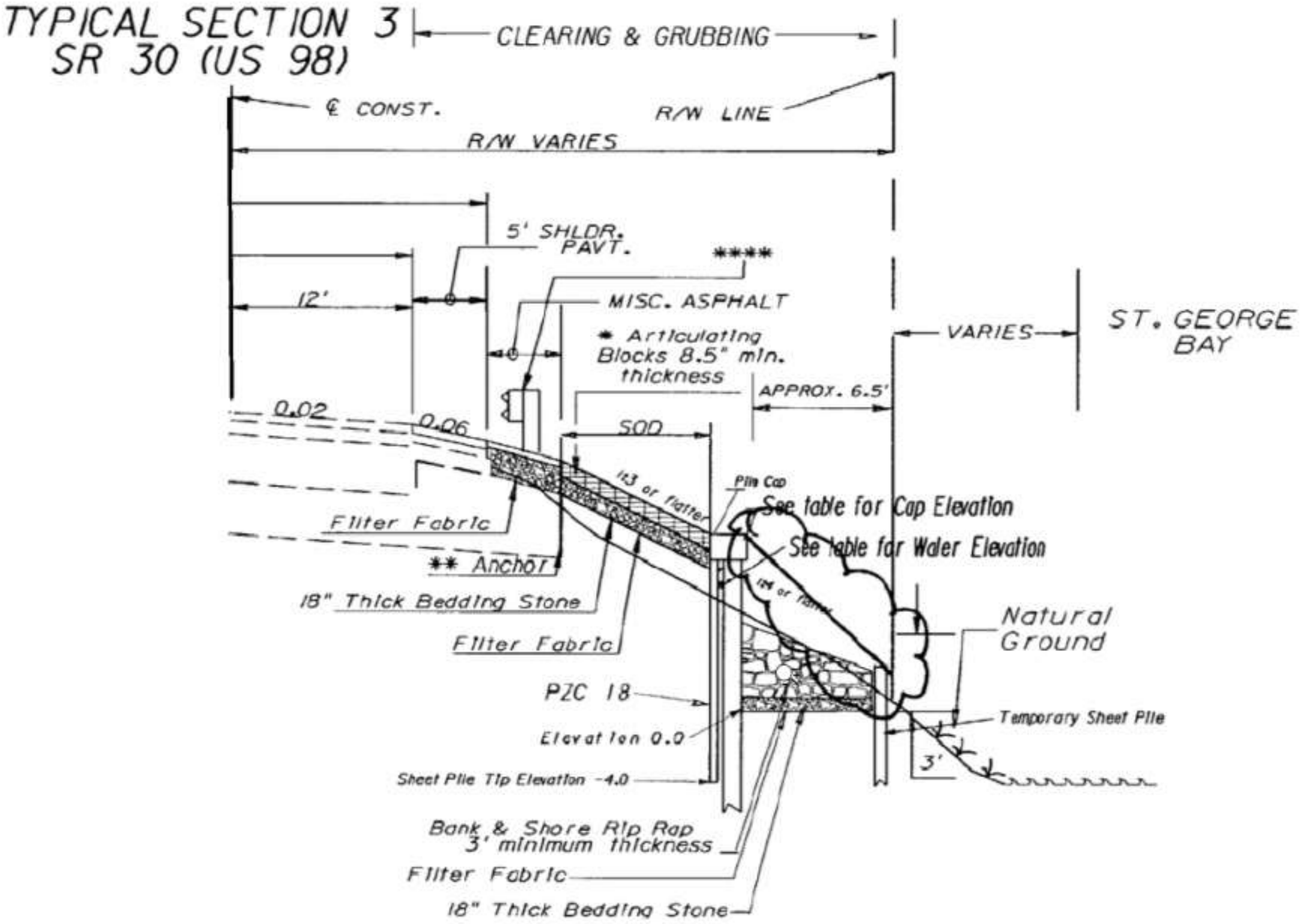

TYPICAL SECTION I
SR 30 (US 98)
CLEARING & GRUBBING
℄ CONST.
MISC. ASPHALT
R/W LINE
R/W VARIES
5' SHLDR. PAVT.
12'
8'
SOD
0.02
0.06
MISC ASPHALT
1:3 or flatter with sod, 6" soil layer and mat. See Detail
Natural Ground
3'
Elev. 0.0
** Anchor
Filter Fabric
Articulating Concrete Block
18" Thick Bedding Stone
Bank & Shore Rip Rap 3' minimum thickness see detail

US 98



TYPICAL SECTION 2
SR 30 (US 98)
CLEARING & GRUBBING
℄ CONST.
R/W LINE
R/W VARIES
5' SHLDR. PAVT.
12'
MISC. ASPHALT
***
SOD
* Articulating Blocks 8.5" min. thickness with soil layer (6") and sod with mat
APPROX. 6.5'
0.02
0.06
1:3 or flatter
Pile Cap
Back fill to approximate original grade
Temp. critical sheet pile may be used at the direction of project administrator.
Filter Fabric
** Anchor
Bedding Stone 18" Thick
Filter Fabric Type D-2
1:4 or flatter
Natural Ground
Pile Lagging
Filter Fabric
3'
18"
Pre-Stress Concrete Pile see table for size and hight
Bank & Shore Rip Rap 3' minimum thickness
Filter Fabric
Bedding Stone 18" thick

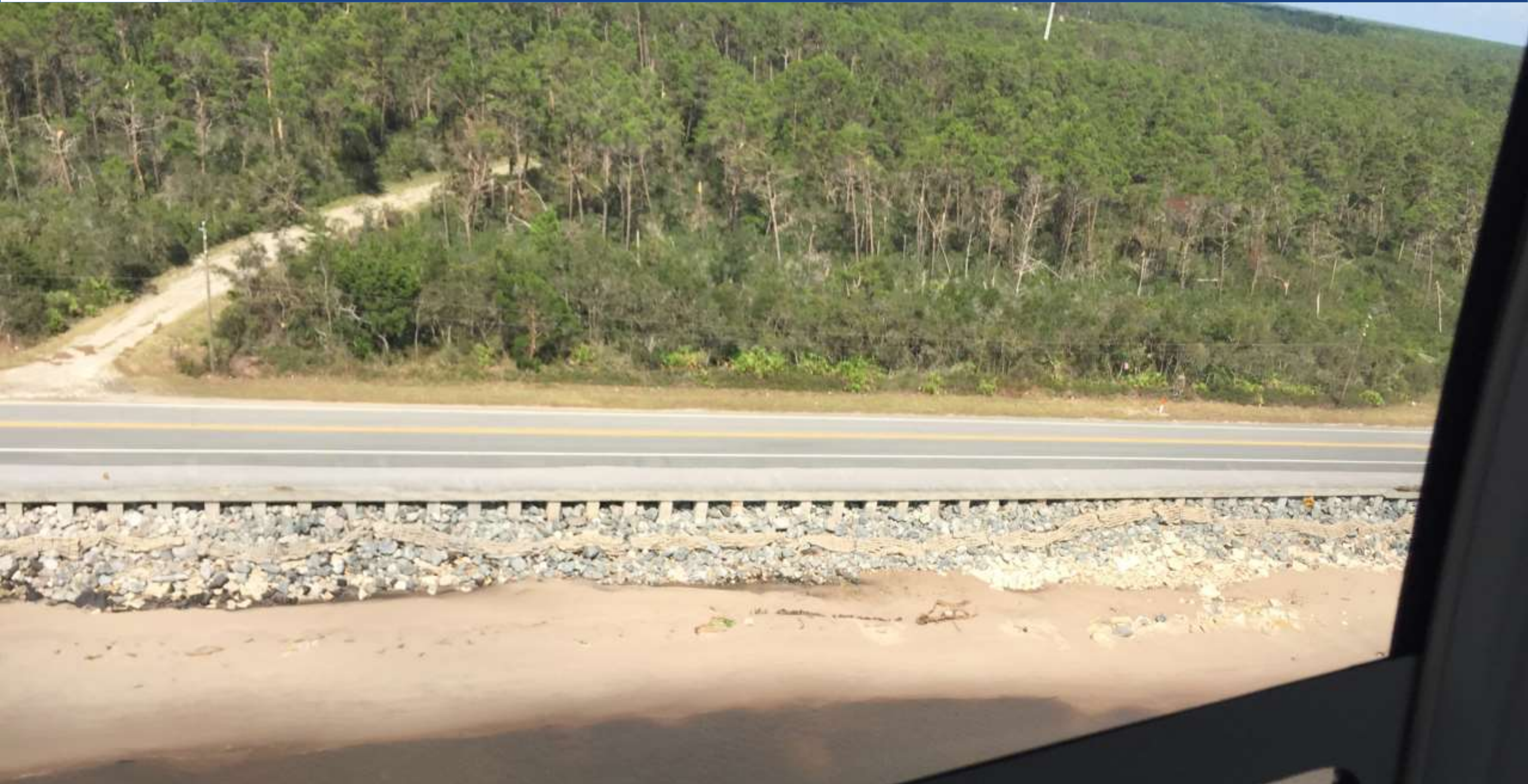
US 98


TYPICAL SECTION 3
SR 30 (US 98)
CLEARING & GRUBBING
℄ CONST.
R/W LINE
R/W VARIES
5' SHLDR. PAVT.
****
12'
MISC. ASPHALT
* Articulating Blocks 8.5" min. thickness
APPROX. 6.5'
VARIES
ST. GEORGE BAY
0.02
0.06
SOD
1:3 or flatter
Pile Cap
See table for Cap Elevation
See table for Waler Elevation
Filter Fabric
** Anchor
18" Thick Bedding Stone
Filter Fabric
Natural Ground
PZC 18
Temporary Sheet Pile
Elevation 0.0
3'
Sheet Pile Tip Elevation -4.0
Bank & Shore Rip Rap 3' minimum thickness
Filter Fabric
18" Thick Bedding Stone

US 98

US 98

US 98



US 98

US 98

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US 98

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US 98

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Mexico Beach

Mexico Beach

Mexico Beach

Mexico Beach

Mexico Beach

Mexico Beach

Questions